Periprosthetic Osteolysis after Total Wrist Arthroplasty

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Abstract

Background and Literature Review Periprosthetic osteolysis (PPO) after second- or third-generation total wrist arthroplasty (TWA), with or without evident loosening of the implant components, has previously been reported in the literature, but rarely in a systematic way.

Purpose The purpose of this study was to analyze the prevalence, location, and natural history of PPO following a TWA and to determine whether this was associated with prosthetic loosening.

Patients and Methods We analyzed 44 consecutive cases in which a RE-MOTION TWA (Small Bone Innovations Inc., Morrisville, PA, USA) had been done.

Results We found significant periprosthetic radiolucency (more than 2 mm in width) at the radial component side in 16 of the cases and at the carpal component side in 7. It developed gradually juxta-articularly around the prosthetic components regardless of the primary diagnosis, and seemed to stabilize in most patients after 1–3 years. In a small percentage of the patients, the periprosthetic area of bone resorption was markedly larger. In general, radiolucency was not related to evident loosening of the implant components, and only five carpal components and one radial had subsided or tilted.

Conclusion Periprosthetic loosening is frequent following a TWA. In our series it was not necessarily associated with implant loosening and seemed to stabilize within 3 years. Close and continued observation is, however, recommended.

Level of Evidence Therapeutic IV

Keywords
- wrist
- arthroplasty
- osteolysis
- radiolucency

Periprosthetic osteolysis (PPO) is a biologic process of bone resorption, seen as radiolucent lines or areas on radiographs. It has been well described after total joint replacement, mostly in the hip. Its causes are multifactorial, and it is supposed that the occurrence of debris, especially polyethylene, may play an important role.[1,2] A correlation between polyethylene wear and implant loosening has been found in several clinical studies,[3] and it is documented that polyethylene wear is diminished by the use of highly cross-linked polyethylene.[4,5] Furthermore, it is well known that some patients develop focal PPO without implant loosening.[6]

In a recent study, based on data retrieved from the International RE-MOTION Register, it was brought to light that PPO may occur frequently after total wrist arthroplasty (TWA): signs of implant loosening were reported in 6 of 52 cases (11%) seen at follow-up 5–9 years after operation and PPO without implant loosening in another 11 cases (21%),[7] but these figures were only estimates, because it was left to the judgment of the surgeons who contributed to the register

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whether PPO was considered present or not. Moreover, no attempt was made to quantify the magnitude of PPO.

The purpose of this study was to analyze the prevalence, location, and natural history of PPO following a TWA and to determine whether this was associated with prosthetic loosening.

Materials and Methods

We included radiographs of consecutive patients operated in two wrist centers performing a TWA using the RE-MOTION prosthesis (Small Bone Innovations Inc., Morrisville, PA, USA) on a regular basis. In these centers, we routinely followed the patients with annual clinical and radiographic examinations, including standard posteroanterior and lateral views of the wrist after a TWA. The mean follow up was 3.7 years (2–6 years). We excluded patients with less than 2 years follow-up and cases that had been revised with removal of implant components for other reasons than loosening. Demographics are shown in ►**Table 1**.

We defined radiological spots for the measurement of radiolucency on digitalized posteroanterior (PA) radiographs (►**Fig. 1**) and measured the maximal width of the radiolucent zones at these spots, perpendicular to the surface of the implant components, using Sectra measurement software (Sectra AB, Linköping, Sweden). Both authors performed the measurements together, one measurement for each spot. We calculated the average of the measurements at zones 1–3, 4–5, 6–8, and 9–10. For example, if the maximal width at location 4 was 3 mm and it was 4 mm at location 5, this would be recorded as an average width of 3.5 mm at zone 4–5. For each patient, we plotted these figures as a function of time.

Furthermore, we measured the angle between the radial component and the long axis of the radius, as well as the angle between the carpal peg and the axis of the third metacarpal.

Finally, we measured the distance between the tip of the radial implant and the tip of the radial styloid, as well as the distance between the tip of the carpal peg and the third carpometacarpal (CMC) joint space. We defined frank loosening of the components as increasing angulation or subsidence over time, based on these measurements.

Table 1 Demographics of 44 patients

Mean age and range at operation	59.7 (34–84)
Sex	12 male, 32 female
Mean follow-up time and range	3.7 (2–6) years
Diagnosis	
• Rheumatoid arthritis	21
• Idiopathic osteoarthritis	10
• Posttraumatic arthritis after distal radius fracture	4
• SLAC wrist (scapholunate advanced collapse)	3
• Miscellaneous (Kienböck, Madelung)	2
• Revision of failed TWA	4

Fig. 1 Spots for the measurement of the width of radiolucency on serial PA radiographs.

Results

Forty-four cases fulfilled the inclusion and exclusion criteria.

The width of radiolucency in zone 1 averaged 0.05 mm (range 0–1), and 0.17 mm in zone 6 (range 0–3.4) respectively, indicating minimal radiolucency at the extremities of the

Fig. 2 Radiolucency 5 years after TWA: There is pronounced radiolucency near the joint but no radiolucent zones at the extremities of the components. Neither was there subsidence or progressive angulation of the implant.

components. By contrast, the width averaged 2.0 (range 0–9) mm at zone 4–5 and 1.0 (range 0–7) mm at zone 9–10, indicating that radiolucency mainly developed juxta-articularly (►**Fig. 2**).

A total of 26 of the 44 patients (59%) had radiolucency of 2 mm or less in zones 4–5, while 37 of 44 patients had radiolucency of less than 2 mm in zones 9–10 (84%). In 15 patients (34%) the radiolucency was between 2 and 4 mm at zone 4–5 and in four patients at zones 9–10 (9%).

►**Fig. 3a**, **b** shows the development of radiolucency at the juxta-articular spots in function of time for each patient: ►**Fig. 3a** shows zones 4–5 and ►**Fig. 3b** shows zones 9–10. In the cases in which the radiolucency was 2 mm or less (mean of zones 4–5, ►**Fig. 3a**) this seemed to remain stable over time. In 14 cases radiolucency at zones 4–5 increased slowly to 2–3 mm and stabilized after 3–4 years. In two cases radiolucency at zones 4–5 developed more dramatically during the first 2 years, although not causing angulation or subsidence of the radial implant. ►**Fig. 4a–c** shows an example of this phenomenon. At zones 9–10, a total of seven patients (16%) had a radiolucency of more than 2 mm at some time during the observation period (►**Fig. 3b**). In two cases the width of radiolucency increased at first but later decreased, as the carpal plate sank into the osteolytic area. The radiographs of the other five patients did not show any subsidence. Conversely, there were three other patients *with* subsidence who did not develop a radiolucency of 2 mm or more. In these cases no radiolucent line appeared because the zone of bone resorption collapsed gradually, as the carpal component sank in the osteolytic area (►**Fig. 5a, b**). The number of patients was too small to draw any conclusions between rheumatoid and nonrheumatoid cases (►**Table 2**).

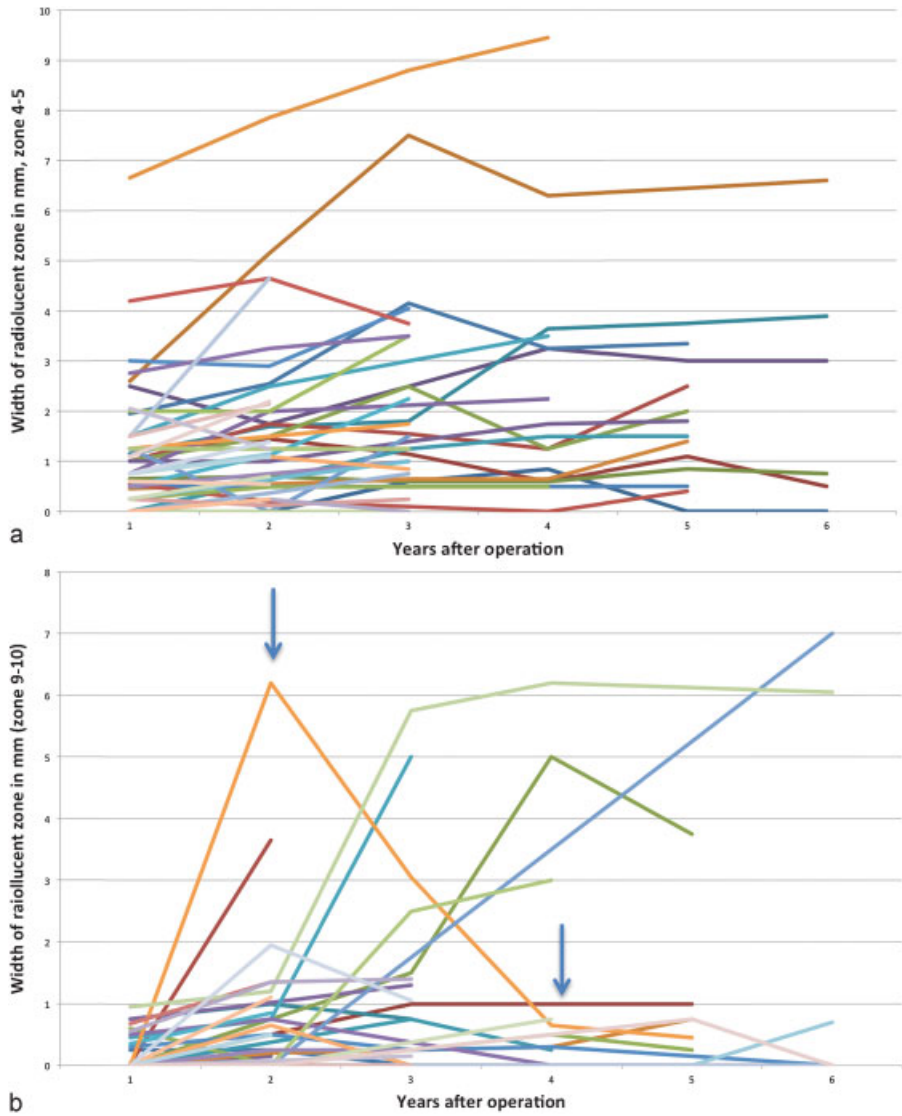

Fig. 3 (**a**) Width of radiolucent zones at zone 4–5 in function of time. Each line represents a single case. X-axis: length of follow-up in years. Y-axis: Width of radiolucency in mm. (**b**) Width of radiolucent zones at zone 9–10 in function of time. Each line represents a single case. X-axis: length of follow-up in years. Y-axis: Width of radiolucency in mm. The arrows indicates a maximal width of radiolucency under the carpal plate at 2 years after operation in this particular case (6.2 mm), and at 4 years, where the radiolucent zone was reduced to almost 0 mm, as the carpal plate sank into the carpus

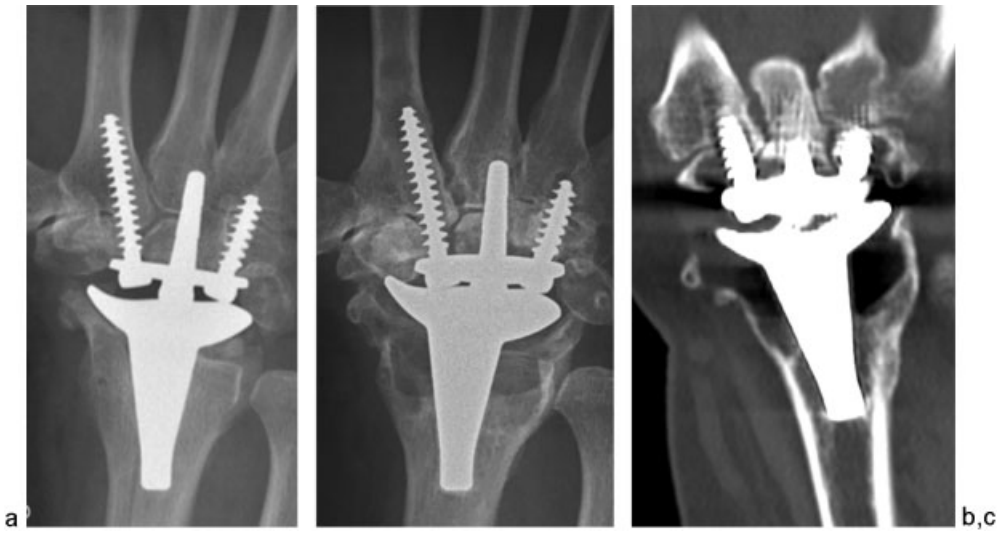

Fig. 4 (**a**) 6 weeks after TWA. Bone grafting was performed ulnarly under the radial component. Because of considerable resection of the carpal bones, the ulnar screw and the central carpal peg cross the CMC joint. No periprosthetic osteolysis. (**b**) The patient had gradually developed a growing radiolucency in zones 4 and 5, here shown at 4 years after operation. The annual radiographs did not reveal any angulation or subsidence of the radial component. Radiolucency is also present around the carpal component, including the peg and the screws. (**c**) A computed tomography (CT) scan 4.5 years after operation confirms periprosthetic osteolysis distally around the radial component but no loosening of this component more proximally. Seemingly, there is a narrow radiolucent line around the extremity of the radial component away from the wrist joint, but this is an artifact created by the O-MAR software. On the other hand, there seems to be a radiolucent area around the screws.

Evident loosening of implant components, defined as progressive angulation or subsidence, was seen in 6 out of 44 cases (14%): five carpal components, one radial. Subsidence was seen in six cases: Radial subsidence started to be visible at 2 years in one patient, carpal subsidence at 2 years in three patients, at 3 years in one patient, and at 4 years in one patient.

Discussion

PPO after second- or third-generation total wrist arthroplasty (TWA), with or without frank loosening of the implant components, has previously been reported in the literature, but rarely in a systematic way.[8–24] Eight studies reported osteolysis without *evident* loosening of the implants.

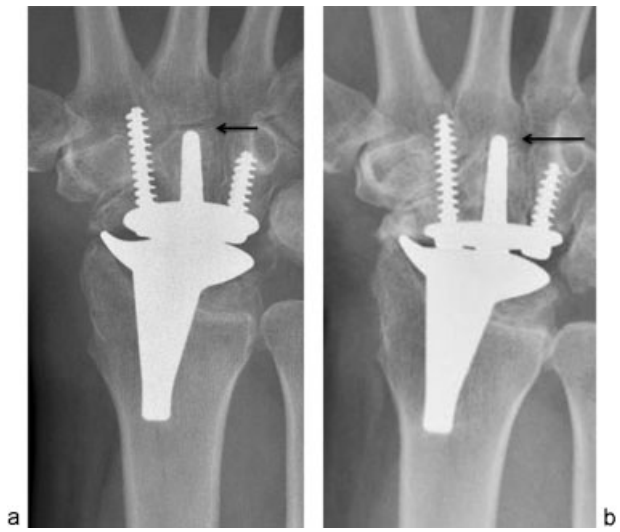

Fig. 5 (**a**) 6 weeks after operation. The carpal peg does not penetrate the third CMC joint. (**b**) Same case as in **a**, 2 years after operation. The carpal plate has sunk in the carpal bones and the carpal peg penetrates the third metacarpal.

Cobb and Beckenbaugh analyzed a consecutive series of 64 Biaxial TWAs systematically, with a follow-up time of 5–9 years (average 6.5).[25] In 12 out of 46 wrists (26%), there was progressing radiolucency at the carpal component, seven of which were revised (15%). Subsidence of the carpal component was present in seven cases after 1 year and in 20 (43%) cases at final follow-up.

Groot et al published a case with PPO 11 years after implantation of a Biax implant, in which macrophages containing polyethylene and metallic particles were found at the histopathological examination.[26]

Ward et al have followed 24 rheumatoid wrists with a cemented Universal I TWA. Among the 19 cases with a follow-up time of more than 5 years, nine had been revised due to loosening of the carpal component. The authors stated that there was polyethylene wear and metallosis in all these cases.[21]

Similar osteolysis has been reported using metal-on-metal implants as well. Radmer et al reviewed APH implants, which are titanium-coated at the articular surfaces, without intercalated polyethylene.[8] Follow-up period was 52 months (range, 24–73). Radiolucent lines larger than 2 mm were present in 30 of 36 patients (83%), including 30 on the metacarpal side and 5 on the radial side. Reigstad et al reported focal osteolysis in the radius around a metal-on-metal implant in three patients without affecting the clinical outcome, the largest including most of the radial styloid, which stabilized after one year.[16]

Bone resorption has also been observed frequently after ulnar head replacement, in which no artificial components

Table 2 Width of radiolucent zone at zones 4–5 and zones 9–10 in different diagnostic groups

	Width of radiolucency at zone 4–5 (mean of zones 4 and 5)	Width of radiolucency at zone 9-10 (mean of zones 9 and 10)
Rheumatoid	2.1 mm	0.8 mm
Nonrheumatoid	1.7 mm	0.8 mm

articulate with each other. This resorption seems to stabilize after 6–12 months and is ascribed to stress shielding.[27,28]

In our series, juxta-articular radiolucency larger than 2 mm was seen in 18 of 44 cases (41%), in 11 at the radial side only, in two at the carpal side only, and in five at both sides: In some patients it was visible already 1 year after operation, while in other patients it did not appear at all, even 6 years after operation (►**Figs. 3a, b**). We attempted to treat one of the cases that developed radiolucency without loosening of the implant, by bone grafting, because this rheumatoid patient presented with an increasing cystic ganglion at the dorsum of the wrist. Radiolucency recurred within 2 years (►**Fig. 6a–c**). No samples were collected for histopathological examination in this case. The main strength of our study is that we have followed a consecutive group of patients with annual radiographical examinations,. We were able to answer the questions formulated in the introduction of this paper with reasonable validity. We found significant periprosthetic radiolucency, more than 2 mm in width, relatively frequently: at the radial component side in 36% of the cases and at the carpal component side in 16%. It developed gradually juxta-articularly around the prosthetic components during the first years after operation, regardless of the primary diagnosis, and seemed to stabilize in most patients after 1–3 years at a level of a few mm. In a small percentage of the patients, the periprosthetic area of bone resorption was markedly larger. This number of patients is too small to indicate clearly whether it stabilizes after 2–3 years or is continuously progressing. On the other hand, radiolucency did not at all develop at the extremities of the components to the same extent as near the joint and in general was not clearly related to evident loosening (angulation or subsidence over time): only one radial component was loose at latest follow-up, and only two of the carpal implants with major periprosthetic bone resorption had subsided. Weaknesses of this study include the fact that the examiners were not blinded and there was no calculation of intraobserver agreement. We did not perform histology to rule out osteolysis possibly due to polyethylene wear particles.

Our data, based on a single metal-on-polyethylene implant, do not allow us to draw any conclusion on the possible causes of bone resorption without implant loosening. From the literature cited above, several possible mechanisms could play a role: metallic or polyethylene-induced osteolysis or stress-shielding. The mere simultaneous occurrence of debris and radiolucency is not in itself a proof of a causal relationship between these two phenomena. Further investigations are necessary to elucidate the question. It is difficult to infer any practical consequence of our findings for the time being. So far, we have adopted the policy of not revising implants with PPO in patients who did not have pain. Our single case that was bone-grafted and in which the PPO recurred rapidly does not prompt us to recommend this procedure. We are inclined to recommend close observation of these cases, at least until it is clear whether they stabilize or continue to progress, which increases the chances of implant loosening.

Fig. 6 (**a**) Periprosthetic radiolucency, confined to the juxta-articular periprosthetic areas, 6 years after TWA. (**b**) Same case as in **a**, after bone grafting under the carpal plate. (**c**) Recurrent radiolucency under the carpal plate 2 years after bone grafting. No subsidence.

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Conflict of Interest
None

References

1 Zhu YH, Chiu KY, Tang WM. Review Article: Polyethylene wear and osteolysis in total hip arthroplasty. J Orthop Surg (Hong Kong) 2001;9(1):91–99
2 Orishimo KF, Claus AM, Sychterz CJ, Engh CA. Relationship between polyethylene wear and osteolysis in hips with a second-generation porous-coated cementless cup after seven years of follow-up. J Bone Joint Surg Am 2003;85-A(6):1095–1099
3 Oparaugo PC, Clarke IC, Malchau H, Herberts P. Correlation of wear debris-induced osteolysis and revision with volumetric wear-rates of polyethylene: a survey of 8 reports in the literature. Acta Orthop Scand 2001;72(1):22–28
4 McCalden RW, MacDonald SJ, Rorabeck CH, Bourne RB, Chess DG, Charron KD. Wear rate of highly cross-linked polyethylene in total hip arthroplasty. A randomized controlled trial. J Bone Joint Surg Am 2009;91(4):773–782
5 Kurtz SM, Gawel HA, Patel JD. History and systematic review of wear and osteolysis outcomes for first-generation highly crosslinked polyethylene. Clin Orthop Relat Res 2011;469(8):2262–2277
6 Goosen JHM, Castelein RM, Verheyen CCPM. Silent osteolysis associated with an uncemented acetabular component: A monitoring and treatment algorithm. Curr Orthop 2005;19:288–293
7 Boeckstyns ME, Herzberg G, Merser S. Favorable results after total wrist arthroplasty: 65 wrists in 60 patients followed for 5–9 years. Acta Orthop 2013;84(4):415–419
8 Radmer S, Andresen R, Sparmann M. Total wrist arthroplasty in patients with rheumatoid arthritis. J Hand Surg Am 2003;28(5):789–794
9 Lirette R, Kinnard P. Biaxial total wrist arthroplasty in rheumatoid arthritis. Can J Surg 1995;38(1):51–53
10 Stegeman M, Rijnberg WJ, van Loon CJ. Biaxial total wrist arthroplasty in rheumatoid arthritis. Satisfactory functional results. Rheumatol Int 2005;25(3):191–194
11 Courtman NH, Sochart DH, Trail IA, Stanley JK. Biaxial wrist replacement. Initial results in the rheumatoid patient. J Hand Surg [Br] 1999;24(1):32–34
12 Harlingen Dv, Heesterbeek PJ, J de Vos MHigh rate of complications and radiographic loosening of the biaxial total wrist arthroplasty in rheumatoid arthritis: 32 wrists followed for 6 (5–8) years. Acta Orthop 2011;82(6):721–726
13 Kretschmer F, Fansa H. BIAX total wrist arthroplasty: management and results after 42 patients [in German]. Handchir Mikrochir Plast Chir 2007;39(4):238–248
14 Rizzo M, Beckenbaugh RD. Results of biaxial total wrist arthroplasty with a modified (long) metacarpal stem. J Hand Surg Am 2003;28(4):577–584
15 Fourastier J, Le Breton L, Alnot Y, Langlais F, Condamine JL, Pidhorz L. Guépar's total radio-carpal prosthesis in the surgery of the rheumatoid wrist. Apropos of 72 cases reviewed [in French]. Rev Chir Orthop Repar Appar Mot 1996;82(2):108–115
16 Reigstad O, Lütken T, Grimsgaard C, Bolstad B, Thorkildsen R, Røkkum M. Promising one- to six-year results with the Motec wrist arthroplasty in patients with post-traumatic osteoarthritis. J Bone Joint Surg Br 2012;94(11):1540–1545
17 Bidwai AS, Cashin F, Richards A, Brown DJ. Short to medium results using the Remotion total wrist replacement for rheumatoid arthritis. Hand Surg 2013;18(2):175–178
18 Herzberg G, Boeckstyns M, Sorensen AI, et al. "Remotion" total wrist arthroplasty: preliminary results of a prospective international multicenter study of 215 cases. J Wrist Surg 2012;1(1):17–22
19 Rahimtoola ZO, Rozing PM. Preliminary results of total wrist arthroplasty using the RWS Prosthesis. J Hand Surg [Br] 2003;28(1):54–60
20 Rahimtoola ZO, Hubach P. Total modular wrist prosthesis: a new design. Scand J Plast Reconstr Surg Hand Surg 2004;38(3):160–165
21 Ward CM, Kuhl T, Adams BD. Five to ten-year outcomes of the Universal total wrist arthroplasty in patients with rheumatoid arthritis. J Bone Joint Surg Am 2011;93(10):914–919
22 Ferreres A, Lluch A, Del Valle M. Universal total wrist arthroplasty: midterm follow-up study. J Hand Surg Am 2011;36(6):967–973
23 Gellman H, Hontas R, Brumfield RH Jr, Tozzi J, Conaty JP. Total wrist arthroplasty in rheumatoid arthritis. A long-term clinical review. Clin Orthop Relat Res 1997;(342):71–76
24 Bosco JA III, Bynum DK, Bowers WH. Long-term outcome of Volz total wrist arthroplasties. J Arthroplasty 1994;9(1):25–31
25 Cobb TK, Beckenbaugh RD. Biaxial total-wrist arthroplasty. J Hand Surg Am 1996;21(6):1011–1021
26 Groot D, Gosens T, Leeuwen NC, Rhee MV, Teepen HJ. Wear-induced osteolysis and synovial swelling in a patient with a metal-polyethylene wrist prosthesis. J Hand Surg Am 2006;31(10):1615–1618
27 Herzberg G. Periprosthetic bone resorption and sigmoid notch erosion around ulnar head implants: a concern? Hand Clin 2010;26(4):573–577
28 van Schoonhoven J, Fernandez DL, Bowers WH, Herbert TJ. Salvage of failed resection arthroplasties of the distal radioulnar joint using a new ulnar head prosthesis. J Hand Surg Am 2000;25(3):438–446